

International Journal of Horticultural Science 2010, 16 (4): 75–79.  
Agroinform Publishing House, Budapest, Printed in Hungary  
ISSN 1585-0404

# Economics of apple-storage I: Comparative time series analysis of apple producer prices in Germany and Hungary

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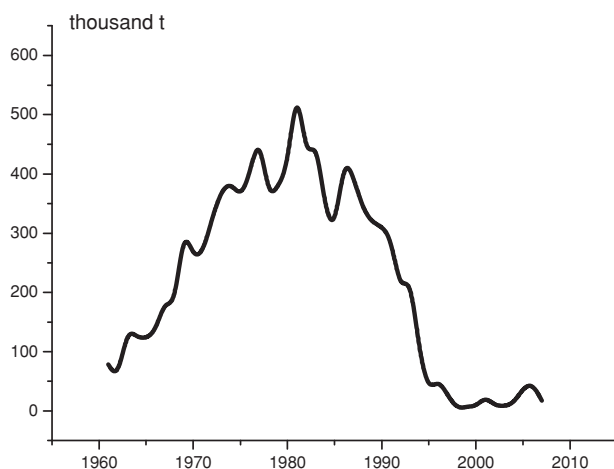
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**Summary:** Based on standard econometric methods the article analyses the time series of fresh apple producer prices in domestic markets of Germany and Hungary. In Germany, as a consequence of high storage capacities the quantity offered in different parts of the season is relatively stable, that's why only a rather limited price increasing can be detected. In Hungary, as a consequence of the limited storage capacity this fluctuation is much more important. The modern methods of time series analysis (ARIMA models, stepwise regression) can be efficiently applied for forecasting of price movements.

**Key words:** seasonality, time series analysis, spectral analysis, ARIMA models

## Introduction

The Hungarian apple production has been in a deep-rooted crisis after radical political and economic changes in the Central-and Eastern Europe in late eighties. However the agro-ecologic conditions are favourable for the high-quality and quantity production of apple, a sharply decreasing tendency of production and fresh –apple export (*Fig. 1*) can be observed.



**Figure 1.** Dynamics of Hungarian fresh apple export (1961–2007)  
Source: FAO Faostat® database

Parallel with this tendency, there is a rapid increasing of apple –juice concentrate export. The concentrated apple juice export has achieved 30–50 thousand t during the last years. This

tendency can't be evaluated as an unambiguously positive one, because (1) the value-added content of this product is relatively low, and offers only a limited possibility to utilise the competitive advantage of Hungarian producers; (2) the world market price of apple-juice decreases rapidly as a consequence of increasing supply. For example China has increased its apple-juice export between 1990 and 2007 from zero to more than 1 million t, realising more than 1.2 billion USD income.

The average prices of Hungarian fresh apple export are considerably lower, than the export-prices of states with developed apple production and logistics sector (*Table 1*).

**Table 1.** Fresh apple export prices of some important apple producing countries (2002–2007 f.o.b. average export prices)

Country	average export prices (USD/t)	percentage of the Hungarian export price
Australia	1094	293
France	856	229
Germany	778	209
Netherlands	775	208
Italy	773	207
Austria	719	193
Spain	603	162
Chile	520	139
Argentina	471	126
Greece	431	116
Hungary	373	100

Source: own calculations, based on Faostat® foreign trade database

The decreasing market share and the relatively low prices, parallel with considerable increasing of import –quantity highlight the low level of competitiveness of Hungarian fresh apple sector. The improvement of this situation necessitates the modernisation of the Hungarian apple production and logistics. In this process the upgrading of cool storage capacities plays an important role.

Economic debates on place and role of cold-storage have considerable traditions in Hungarian fruit-economics (Harsányi, 2005).

The aim of current series of article is the determination of economic and marketing aspects of apple-storage. The research is based on system –analysis approach. In first phase of investigations we consider the cold-storage as an open system, which continuously interacts with the environment.

The current series of articles is structured as follows: in first phase we analyse the price dynamics of the fresh apple in two important apple-producing states of Europe: Hungary and Germany. In next phase of investigation the feasibility of investments into the development of cold-storage facilities will be presented.

### **Hypothesis development**

Based on our preliminary experiences and deep-interviews of leading specialists of apple –trade in Hungary we have developed the hypotheses as follows:

H<sub>1</sub>: there are cyclical patterns in monthly apple-price time series. This cyclical behaviour can be explained by supply-demand relations and the increasing costs of apple-storage.

H<sub>2</sub>: under conditions of increasing pressure of import, neither the Hungarian, nor the German producers have not been able to maintain the former level of producer prices.

H<sub>3</sub>: in case of Germany, where the apple-storage capacities cover practically all of the eating apple production, the differences between the monthly average prices will be much more lower, than in case of Hungary, where the storage-capacities are rather limited.

H<sub>4</sub>: despite of erratic character of price-movements, the monthly apple-prices can be modelled and predicted by a relatively reliable manner, utilising the tools of modern time series analysis, multi-variable statistical methods and neural network analysis.

## **Materials and Methods**

### **Databases**

We have collected the German producers' prices for period from 2003 to 2009. These statistics are open –source information, obtainable via Internet. In Hungary there does not exist any reliable statistical information supply concerning the monthly apple prices, that's why we have used the individual large producers' prices from Szabolcs-Szatmár region. These prices can be considered as a reliably proxy for whole Hungary, because this county gives approximately 70–75% of the Hungarian apple production, the apple-market can be considered as a monopolistic one and there is an intense informal

exchange of information between the large-scale producers. We have focussed our attention for the most important apple-varieties. There does not exist an important trade and –as a consequence of this–a statistical supply on apple-prices for each month in case of each apples.

The yearly time series for different apple varieties, concerning for each months contained 2–3 missing data, which had made the computations difficult, that's why we have recalculated our time series for months, containing valid data. As a consequence of this, one “apple-year” consisted of 9–10 months, and not 12, that's why the periodicity of our time series were 9 or 10 months. For simplicity, we have not altered the German prices, because the average yearly rate of inflation of Euro was 2.35%, expressed in harmonised indices of consumer prices (Eurostat, 2010)

At the same time, the Hungarian inflation has been rather high, the consumer price-level in 2009 has been higher by more than 50% than in 2003. That's why we have deflated the monthly time series by core inflation index of Hungarian National Bank (MNB.hu). This measure of inflation excludes certain items that face volatile price movements, that's why we can estimate a better proxy of changing purchasing power of the Hungarian national currency, that the consumer price index.

### **Mathematical analysis tools**

The periodicity of price –series have been analysed by spectral analysis and autocorrelations. The purpose of spectrum analysis is to decompose the original series into underlying sine and cosine functions of different frequencies, in order to determine those that appear strong and important. The sine and cosine functions are mutually independent, thus it is possible to sum the squared coefficients for each frequency to obtain a periodogram, where the periodogram values at a given frequency show the importance of this frequency (Hamilton, 1994).

The patterns of the price-series have been studied by the autocorrelation. This is a measurement of a signal with itself (Dunn, 2005). A more sophisticated measurement of the correlation between the different elements of the time series is the partial autocorrelation function. According to this measure, given a time series  $z_t$ , the partial autocorrelation of lag  $k$  is the autocorrelation between  $z_t$  and  $z_{t+k}$  with linear dependence of  $z_{t+1}$  through to  $z_{t+k-1}$  removed. This indicator expresses the autocorrelation between  $z_t$  and  $z_{t-k}$  that is not accounted for by lags 1 to  $k-1$ , inclusive.

The forecastings, based on time series analysis have been carried out by autoregressive integrated moving average (ARIMA) models. These models are generally applied in time-series analysis (Box & Jenkins, 1970).

## **Results**

Analysing the price –dynamics of monthly apple-prices it is obvious, that there is a strong periodicity in time series. This periodicity can be intuitively perceived by a simple time-series graph (Fig. 2).

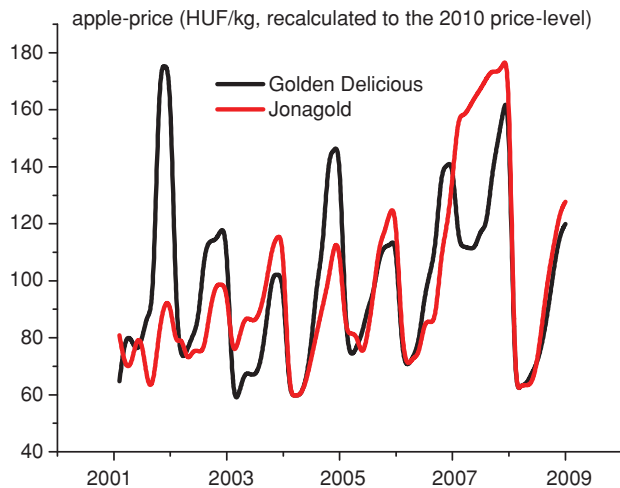


Figure 2. The time series of producer prices of two important apple-varieties in Hungary

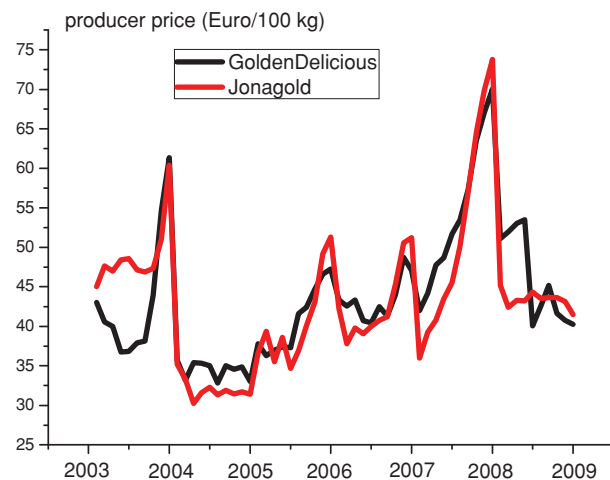


Figure 3. The time series of producer prices of two important apple-varieties in Germany

Analysing the figures it is obvious, that there is an expressed periodicity in the time series of apple prices. To quantify this periodicity, we have used the classic spectral

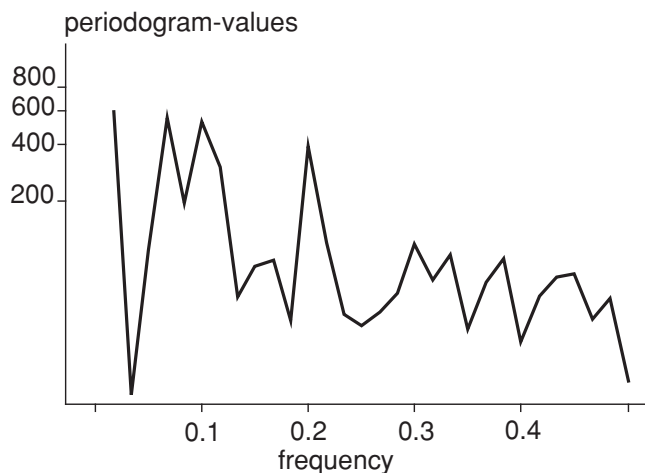


Figure 4. Results of spectral analysis of monthly prices of Gala apple in German market

analysis. Applying this method, it is obvious the –curve shows peaks at 0.1; 0.2...etc frequencies. One of the periodograms is shown in Fig. 4. Taking into consideration, that the apple-season consists for this apple –variety of ten months, this proves the cyclical behaviour of the time series.

Analysing the autocorrelation and the partial autocorrelation functions, it is obvious, that there is a strong autocorrelation between the actual monthly average prices and the average prices of the previous months, but the intensity of this autocorrelation decays exponentially. Neither the autocorrelation function, nor the partial autocorrelation function does not show a significant correlation between the actual and the ten –months earlier prices. This fact highlights, that the prices of the former season in itself are not suitable for prediction of actual monthly prices, that's why more the application of more sophisticated methods seems to be necessary.

Analysing the price-dynamics during the seasons it is obvious, that in Germany the apple –prices are relatively stable during the season. In Hungary, the price differences between the beginning and the end of the season are nearly four times higher, than in Germany (Figs. 5 and 6).

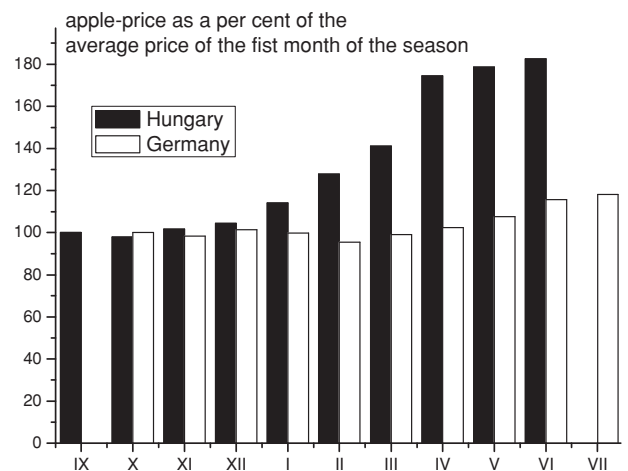


Figure 5. Change of apple-prices during the seasons in Germany and Hungary for Golden Delicious

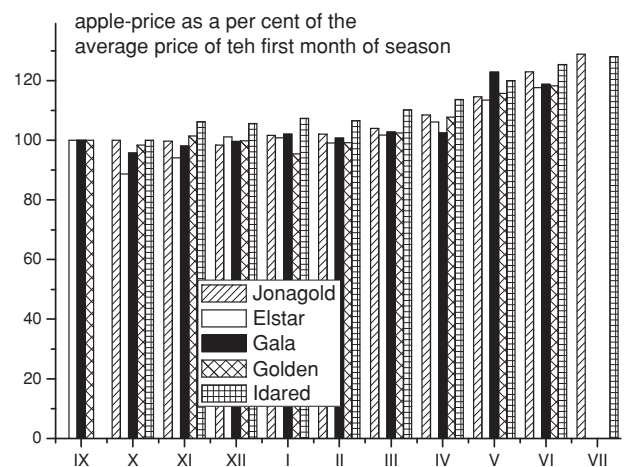


Figure 6. Change of apple-prices during the seasons in Germany for different varieties

Analysis of relative standard deviation of monthly prices in different seasons shows an increasing of volatility in second half of periods. (Figs. 7 and 8)

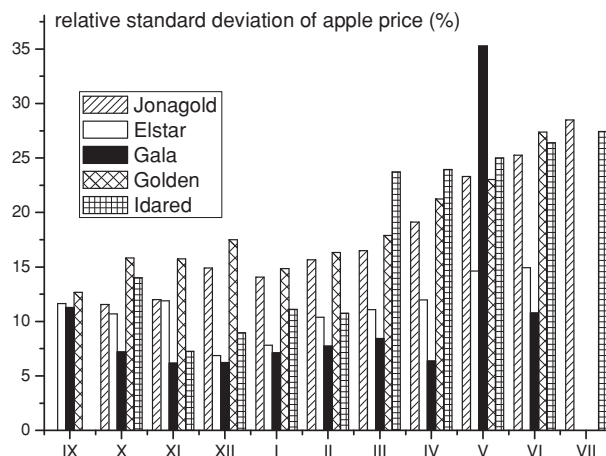


Figure 7. The relative standard deviations of apple price in Germany during the seasons

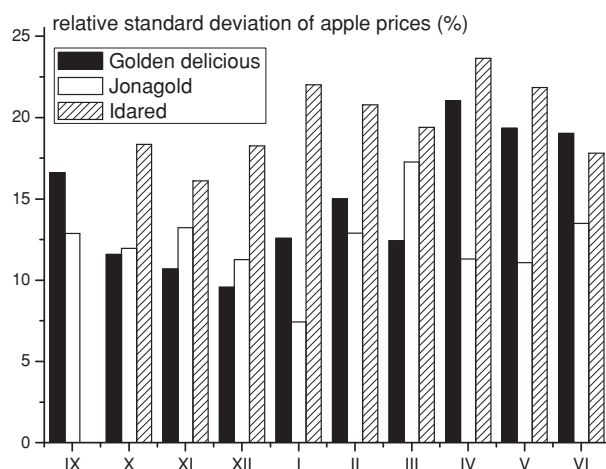


Figure 8. The relative standard deviations of apple price in Hungary during the seasons

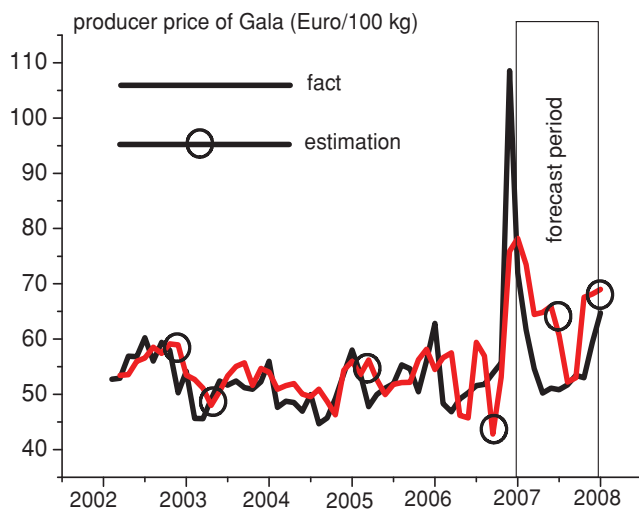


Figure 9. The approximation of the Gala price by ARIMA model and its forecasting

The increasing price-volatility during the seasons highlight the importance of application of sophisticated methods for determination and forecasting of future prices.

Applying the autoregressive integrated moving average (ARIMA) method, a relatively good description of the time series could be achieved. The capability of forecasting of the model applied can be estimated as a rather good (Fig. 9), and can be applied efficiently for the prediction of Hungarian market-too. The best results had been achieved by squaring the original time-series, autocorrelation: 1, moving average: 3, integrative part: 1. Of course, such method can't be forecast such high peaks, as in 2007 season.

## Discussion

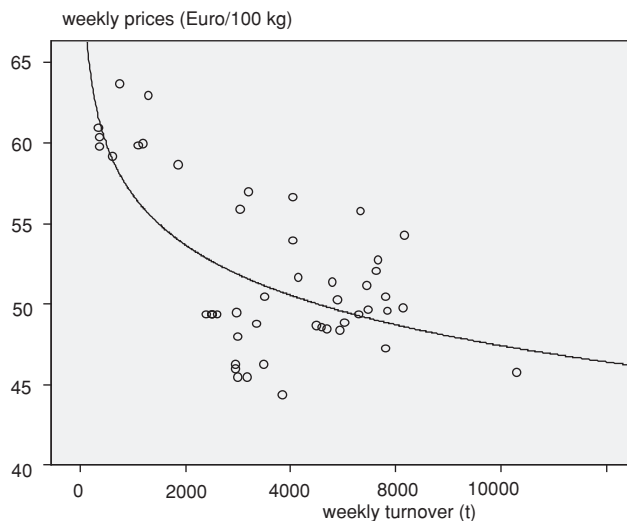
The apple-prices in German and Hungarian market show a strong periodicity, but this cyclical movement of prices show a low level of autocorrelation between the actual and the former data.

The deflated time – series of producer prices in Hungary does not support the hypothesis on decreasing tendency of apple prices in real terms. This fact can be explained by the fact, that there is a demand for high – quality Hungarian apples on the market.

The existence of apple – storage capacities exercises a bumping effect on producer price fluctuation. This hypothesis can be supported by the analysis of German and Hungarian prices. In Germany, where the apple-storage capacities are larger, the price fluctuations are much more limited during the season, than in Hungary, where these capacities are the bottleneck of the system. A further support of this hypothesis is the fact, that there is a strong correlation between the supply and the prices during the seasons. This is in line with the basic principles of microeconomics (. An example of this relation is shown in Fig.

The relation between market –turnover and prices in case of Elstar in 2005/06 season in Germany and the approximation of interrelations with logarithmic function

$$y=97,959-4.511*\ln(x); r^2=0,72$$



It can be proven, that the modern statistical methods of time-series analysis can be used efficiently for the prediction of the prices.

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